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ABSTRACT

It is the author's view that an applied behavioral science approach to the problems of learning and instruction is fundamental to instructional technology. The systems approach may constitute the core technology around which other relevant technologies may be clustered and integrated in application. The author outlines his plan for implementation of a new research and development role for education by focusing on three areas: (1) research and development, (2) development programs for instructional technologists, and (3) relationships between education, private enterprise, and government. (JY)

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THE PHYSICAL SCIENCE VERSUS THE BEHAVIORAL SCIENCE CONCEPT OF INSTRUCTIONAL TECHNOLOGY

by Paul Saettler*

It will be useful here to make a distinction between the physical science (or prevailing conception of instructional technology) and the broader, behavioral science concept. The traditional and physical science concept of instructional technology dominates much of the thinking in both education and industry and defines instructional technology largely in terms of hardware--language laboratories, slide projectors, simulation devices, demonstration apparatus, videotape machines, computers, etc. The narrowness of the physical science concept is such that it tends to view instructional media as aids to instruction and to be preoccupied with the effects of devices and procedures rather than with learning and with the selection and organization of content for reflective problem solving. Closely related to this view, is the widely held presumption that a technology of machines or a collection of techniques is somehow equivalent to a science and technology of instruction. As a consequence, someone orders a number of overhead projectors and dumps them into classrooms where no one knows what to do with them; or a school installs a closed-circuit television system or a language laboratory and then leaves the teachers without any guidance or technical assistance in their use.

So far as the purposes of education are concerned, the possibilities opened by modern instrumentation have not usually been understood by those using them for instruction, nor have there been more than a few systematic attempts to design a true technology of instruction. To date,

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it has to be said that the commercial market for educational hardware and software has expanded to a degree which is seriously out of proportion to their intrinsic instructional merit. The trouble is that a rather sophisticated technology of machines has been developed while a technology of instruction hardly exists. What has happened, as a result, is that much of the modern hardware at the educator's disposal is beyond his knowledge or training with regard to its implementation or function within the educational system in which he is working. Unfortunately, the recent introduction of "The Educational Technology Act of 1968" to Congress also largely reflects the physical science concept of instructional technology by its undue stress on hardware.

It is the writer's view that an applied behavioral science approach to the problems of learning and instruction is fundamental to instructional technology. The basic view of the behavioral science concept of instructional technology is that behavioral science theory and research, or other organized knowledge, should be applied in support of the practical art of instruction. Aside from the broad areas of the behavioral sciences (anthropology, psychology, sociology, etc.) and within them, the more specialized areas of learning, group processes, psycholinguistics, bionics, cybernetics, perception, psychometrics, cognition, organization theory and behavior, communication theory, etc., the behavioral science concept of instructional technology may include such related areas as engineering research and development (including human factors engineering) architectural psychology, logistics, game

and decision theory, and operations research. The most important aspect of this concept of instructional technology concerns the application of scientific knowledge to provide a conceptual basis and methodology for the design, development, and evaluation of instruction and instructional products for the purpose of improving the related components of the educational process.

It should be clear from this description of the behavioral science concept of instructional technology that it would call for new organizational arrangements in education and the development of high-level specialists (e.g., systems programers, computer technologists, learning bio-chemists, etc.) and generalists (instructional technologists) who could assume the task of instructional design in a research and development setting.

TOWARD A TECHNOLOGY OF SYSTEMS DESIGN

Many new technologies in other areas of society have important implications for education, but system theory and research is seen as offering a unifying focus for the application of new technologies in the design of instruction. In fact, the systems approach may constitute the core technology around which other relevant technologies may be clustered and integrated in application. Systems engineering--the invention, design, and integration of an entire assembly of equipment (as distinct from the invention and design of the components) geared to the accomplishment of a broad objective--is a concept which has been fundamental to

practical engineering since the beginning of the industrial revolution. One of the most successful applications of the systems concept in the military sphere was the development of weapons systems. The systems concept has been applied in the development of man-machine systems in space research.

Modern systems technology is intimately linked with electronic technology, particularly computers, and with the development of such new branches of mathematics as game and decision theory and operations research. Also, there is the development of self-regulating machines whose fundamental principle is control (feedback) and communcation (messages between machine and environment, and within the machine). This finds its principal expression in cybernetics principles which can be widely applied to educational problems.

It is important to point out that we agree with some recent outspoken critics of systems analysis who assert that the educational system is considerably more complex (for various social and political reasons among others) than other areas (e.g., military, space) in which this technique has already been successfully applied. We also view with suspicion the recent efforts of corporate coalitions to mould education into a system of cultural uniformity through their long-range plans to produce systems of standardized, pre-packaged materials for mediated instruction. Whether instruction is mediated or provided by a live teacher may not be a significant factor in the educational process, but the excessive concern with specifying behavioral objectives tends to

legitimatize those objectives built into the system by commerical producers because they can be easily described in schematic detail and quantitatively measured. Unfortunately, education rarely questions or examines the purposes of systems derived from commercial and military sources.

If teachers are to be bypassed by mediated instruction, for example, then it can be assumed that curricular decisions to be built into multimedia instructional systems will continue to move outside of education. This is not to condemn the concept of a systems approach, but merely to emphasize the importance of control of the production of educational materials and equipment. Consequently, one of the most important principles in the application of the systems approach to instruction is that product research and development must be under the direction and control of the educational establishment. Unless educational control exists over all the components of an instructional system, the testing of materials and procedures against goals and purposes embedded in the system cannot be accomplished.

The dependent role of instructional technology is nowhere better illustrated than in the development of the computer as a teaching tool. Since educators generally lack technical knowledge or understanding of the potential applications of the computer for the improvement of instruction, they are required to rely almost completely on computer manufacturers for the design of computer software. But if we see the computer as another instructional medium, we can see that education must

begin to develop its own technical staffs skilled in computer technology in order to have the in-house expertise required to preserve a choice in selecting instructional strategies. However, the total design of instructional systems demands, primarily, competence in the behavioral sciences and in subject-matter, and it is unlikely that significant educational work can be accomplished with computers or in any other highly technical area without reference to these necessary competencies.

It is obvious that education is not ready to assume responsibility for the kinds of tasks suggested or implied in this memorandum. Unless or until some basic changes occur, the glowing expectations for instructional technology held by many may lead to progressive disillusionment and confusion.

A PROPOSAL FOR INSTRUCTIONAL TECHNOLOGY

Our proposal is designed primarily to implement a new research and development role for education. It is in no sense a fixed blueprint of an instructional technology of the future, but it does indicate in broad outline what could happen if education realized and utilized its potential resources, knowledge, and skills. Whether or not this plan, or details of it, are implemented, one thing is clear: The consequences of not planning well for the future will be that the control and direction of instructional technology will reside, by default, with the education industry whose primary function is not to improve education but to produce profitable products.

We shall elaborate our plan by focusing on three broad areas: (1) research and development, (2) development programs for instructional technologists, and (3) relationships between education, private enterprise, and government.

1. Research and Development. Instructional innovations depend inevitably on existing materials and equipment or on the development of new ones. For example, it is hardly to be expected that new ideas or curricula can be implemented without substantial reliance on textbooks, films, slides, videotapes, and a variety of other materials produced by private enterprise. Yet, we can hardly expect schools and teachers under our present sy tem to develop the necessary skills to produce their own learning packages although there are direct and observable dependencies embedded in materials introduced into the classroom. It is obvious therefore that instructional technology is largely derived from and dependent on private industry. While there is nothing wrong with the idea of private industry serving education as producers of what education is not able to produce itself, it can be easily seen that the widespread use of instructional materials and equipment which educators had no hand in designing or testing means that it is the commercial producers rather than the educators who have much to do with determining the curriculum. Moreover, if the task of carrying out the necessary feasibility studies is left to industry, then the developmental process will be confined largely to those materials and devices for which there is an immediate and substantial market. Since it is frequently too expensive to change the configuration of an adopted or adapted product to accord with particular educational goals, the goals of education must and often do change to accomodate the product or system developed for different purposes. For example, the recent installation of a computer-assisted

instruction system by the Philco-Ford Corporation in the Philadelphia public schools was a direct outgrowth of a research and development program done by Philco-Ford for the United States Government command and control system. It is, incidentally, a prevailing mythology that military and space research and development is necessarily relevant to a far more complex educational system.

On the other hand, it is distressing to note that, too frequently, educational research projects have been presided over by investigators whose personal or institutional prestige has guaranteed federal funding regardless of the intrinsic merit of their research concept or design. When the United States Office of Education funded the establishment of research and development centers and regional laboratories throughout the country a few years ago, there was considerable hope that such an instrumentality would produce a fundamental change in American education and that educational research would become a matter of national policy. Unfortunately, much of the work of the research and development centers and the regional laboratories, to date, has been disappointing due to failure to change the status quo or to consider viable alternatives to instructional procedures or the sacrosanct organization. The relationship of the research and development centers with schools, colleges, and universities has tended to be rather peripheral and meaningless. Their frequent refusal or inability to cope with a number of critical social, financial, political, and technological problems facing American education is nothing less than astounding. Further, their research and

development approach has been fragmetary rather than comprehensive. No attempt, for example, has been made to deal with the total process of designing instructional systems in terms of curriculum development, content organization, media-message design, production of materials and devices, evaluation procedures, preparation of teachers and related specialists, and the relationships and arrangements required for linking all the components of an instructional system into a meaningful educational pattern.

In order to implement a different approach to research and development, we propose a revised and expanded regional research and development model which would focus on the present gap between knowledge production and knowledge application through the management of clusters of experimental schools within the region. Further, it is proposed that R & D Centers enter into contractual relations with school districts which would give the centers full administrative, legal, and financial responsibility and authority. It is further proposed that the contract contain an added proviso that public school personnel be involved in the research operations, planning, instrumentation, data-gathering and analysis, report preparation, and dissemination activities.

The purpose of our proposal is quite clear. It is to create a body of school personnel who see the value of the empirical-inductive mode of thinking and to develop a profession that turns to research to solve problems, not to justify what it is doing or happens to think is a good idea. Many administrators and teachers simply ignore good research

either because it is laboratory research, or because it was not done in their district. An analysis of the Elementary and Secondary Act Title III projects seems to indicate that doing research in a school setting is not necessarily going to improve educational research nor will it automatically solve educational problems. If research is going to improve educational practice, the practitioners must be interested in and must be engaged in some phase of the process.

Our R & D Center model would provide leadership in creating teacher research teams to formulate proposals for research efforts. In this way the schools could be engaged in doing research on problems they want to solve. Experimental classrooms could be established where atypical instructional procedures would be the rule, extended observation and testing could take place, and where creative experimental treatments could be employed over a relatively long period of time. For example, one experimental theme might reflect the cognitive-field approach; another, the operant conditioning approach. Other experimental approaches might derive their themes from organizational patterns, values, individualization of instruction, creativity, etc. Thus the R & D Centers would provide an ideal experimental setting which the contracting schools themselves would be unable to offer. Selected educational administrators and classroom teachers could spend at least one year or longer working with the Center for purposes of observation and participation in educational research along with behavioral scientists. They would return later to their own schools to provide leadership in innovations which had been experimentally verified.

There is at present a serious gap between research and application that cannot be spanned either by the researcher or by the teacher, or even through the blending of efforts of these two. Since there is a growing conviction that more attention must be given to the developmental process if research knowledge is to be utilized, our model encompasses the establishment of educational products development centers and the spawning of a new breed of instructional technologist or educational designer.

We feel that the development function of the R & D Centers cannot be fully implemented until educational products are developed within the R & D Centers themselves. A major task under this function would involve the preparation of design specifications for educational products (materials, equipment, learning packages, systems, etc.), and the offering of contracts for the production, evaluation, and distribution of these products to private enterprise through competitive bidding. In other words, the relationship of R. & D Centers and commercial manufacturers would be no different than that between industry and other sectors of society in terms of technological control. It is envisioned that such a relationship would ensure rigorous standards of evaluation and quality control as well as professional control over the whole process by which new curriculum ideas and instructional innovations are implemented.

Since the federal government has already made a beginning in converting research knowledge into instructional materials through the establishment of regional laboratories, it is suggested that some of

these laboratories be transferred to the jurisdiction and control of the R & D Centers. Thus a total developmental process, from basic through applied investigation, to design and development, innovation or production, and evaluation, may be achieved in one place.

An important part of this model would be the development of a new instructional technologist who would combine skills that are urgently needed and that are not now taught. As will be seen in the following section, recommendation is made for the funding of developmental training programs for instructional technologists at those few, rather easily-identified institutions, long active in, or currently concerned with this problem. Therefore, it is further recommended that we develop and test prototypes of the R & D Centers we have described and locate them at those institutions that are providing leadership in the field of instructional technology. After these models have been tested in practice, we can begin to replicate them throughout the country.

2. Developmental Programs for Instructional Technologists. There has arisen considerable anxiety in some quarters concerning the adequacy of present curricula and environments for the nurture and cultivation of instructional technologists who can coordinate the developmental process. The programs that do exist at these few universities who are recognized leaders in this field have developed or are developing from programs which were essentially planned for the training of audiovisual specialists. It is now recognized by many that a new training program is called for which will develop a person competent in educational research, who can combine media and messages for effective learning, and coordinate and manage teams of specialists in diverse technologies in the design, development and evaluation of instructional systems. Without the development of a sufficient number of these new instructional technologists, education will not be able to undertake the kinds of instructional tasks envisioned in this memorandum nor will it gain technological control of its future development.

The training programs for instructional technologists clearly call for considerable variety and flexibility. There must be ample opportunity and encouragement to interact with the diversity of disciplines found in a college or university community. The model proposed here is designed to implement the behavioral science concept of instructional technology defined earlier in this memorandum. For example, the biochemist could contribute to the understanding of drugs and brain extracts to enhance learning; the neurologist to the functioning of internal neural systems

(neural communications); the architectural psychologist to the relationship of space and form to effective learning environments; the human factors engineer to the study of living systems in transactions with their environments; the cognitive psychologist to an understanding of cognition and problem solving; the communication specialist to the use of media and message forms; the social psychologist to construction of models of small groups and interpersonal behavior; the computer specialist to methods for simulating entire instructional systems. In other words, there must be opportunity for interaction with a diversity of disciplines and technologies. In this sort of environment, students can pursue their interests while becoming involved in ongoing research projects. It should be emphasized strongly at this point that the training program should develop a perspective which would stress the importance of maintaining technological control on the design, development, and evaluation of educational products.

We have presented a general, long-range proposal for the training of instructional technologists in full recognition that at present such an ambitious program is handicapped both by a lack of adequate personnel and financial resources.

Therefore, as is suggested in the previous section, we propose that the federal government sponsor such developmental training programs for instructional technology, starting with those easily identified institutions which have already provided leadership in this area and those qualified institutions now actively initiating such programs. Since it

is obvious that such programs would best succeed in an R & D Center context, the value of establishing new R & D Centers at institutions undertaking developmental training in instructional technology is evident. But the long-range goals seem clear: instructional technology must be transformed into an applied science. To do so, it will need a large number of developmental instructional technologists who value and use applied behavioral science and who can create the patterns and combinations of media and materials required to solve problems of learning and motivation.

3. Relationships Between Education, Private Industry, and Government.

It is clear that if R & D Centers are to direct, to a great extent, the activities of persons working under contract in private industry, then new relationships will be required and new methods of evaluating and reporting on results will have to be developed. In any event, the present system of technological development and materials production must be changed to meet the growing needs of education. The extent to which industry and education can work together toward solutions to the problems of education will have a long-range effect on the quality of education.

It appears that any relationship between education and industry which does not provide for an interchange of personnel is not likely to be very productive. Not only is this type of arrangement advisable for mutual understanding of the constraints under which both education and industry operate, but it is essential for providing technical training to educational personnel and providing some direct contact for industry personnel with the problems of the classroom. In this connection, it is suggested that some type of leave of absence be instituted for educators to serve full time in industry and that industry personnel do likewise in education. Also, some joint appointment plan might be devised. One prototype of such a partnership between education and industry now exists in the joint undertaking of the University of Pittsburgh Learning Research and Development Center, the Pittsburgh Public Schools, and the General Learning Corporation to experiment in individualized learning for young children.

It is further proposed that private industry and foundations share with the federal government the cost of developing and evaluating educational products and instructional systems at R & D Centers. Although the federal government might in some cases make direct contracts with commerical manufacturers, this contracting function should remain, basically, with the R & D Centers. As is well known by now, all materials produced under contract with the federal government go immediately into public domain, and this involves a host of legal and ethical questions which may be solved more easily outside the realm of the federal government. In any event, some policy would have to be developed whereby schools, colleges, universities, and private industry could all share in the use of and profit from educational products in whose research and development they are involved.